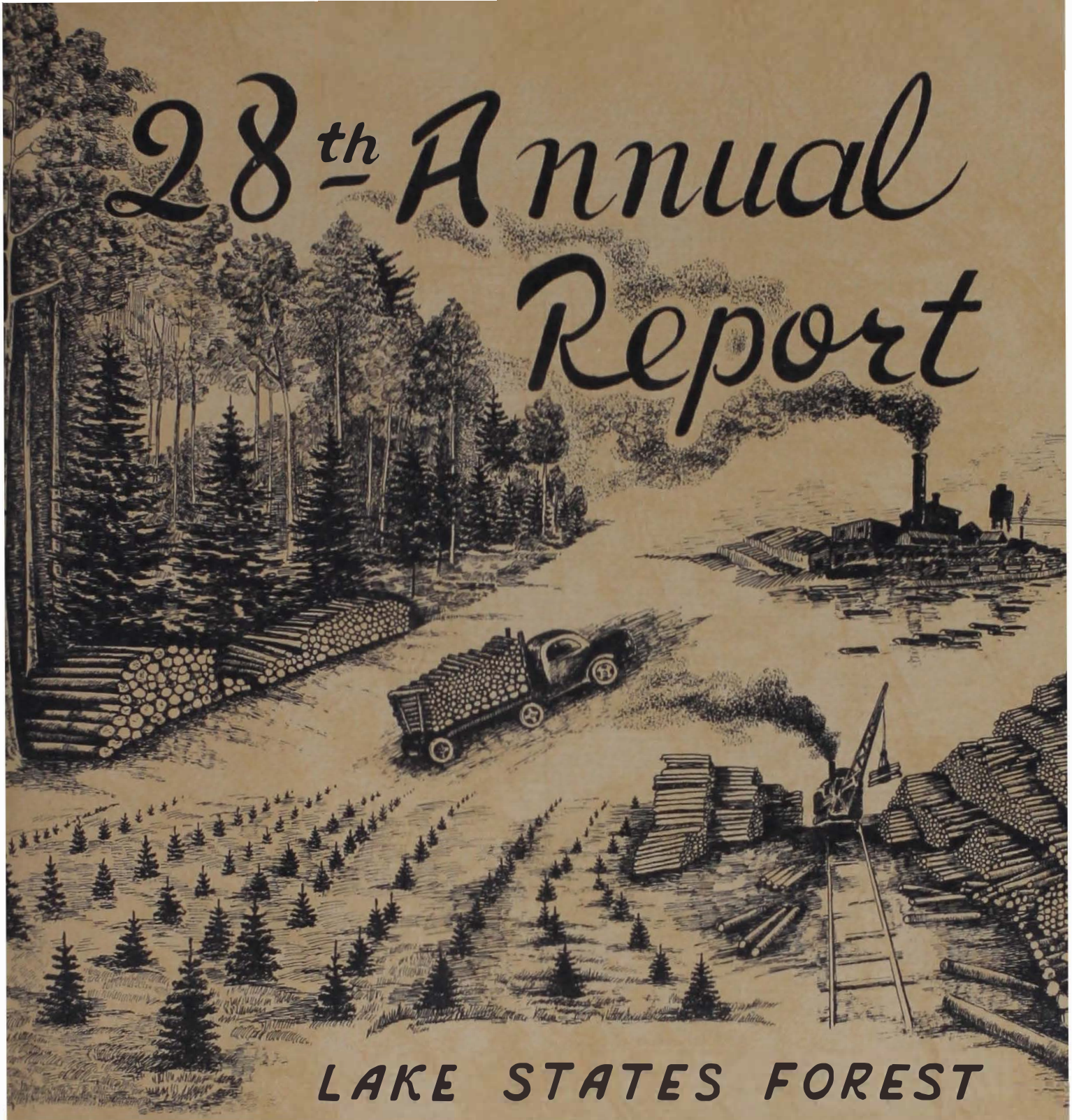

28th Annual Report

LAKE STATES FOREST EXPERIMENT STATION

M.B. DICKERMAN, DIRECTOR

ST. PAUL, MINNESOTA

1951

The Lake States Forest Experiment Station is located at University Farm, St. Paul 1, Minnesota. It is a regional branch of the United States Forest Service and is maintained in cooperation with the University of Minnesota. Through federal legislation, it is authorized to carry on forest research for the benefit of all forestry agencies in the region, including public forest services, wood-using industries, farmers, and other forest users.

The territory in which the Station operates includes the States of Michigan, Wisconsin, Minnesota, and North Dakota. In addition to the central office in St. Paul, field offices are located at East Lansing and Marquette, Michigan; Rhinelander, Wisconsin; and Grand Rapids, Minnesota.

26TH ANNUAL REPORT OF THE

LAKE STATES FOREST EXPERIMENT STATION

For the Calendar Year 1951

Lake States Forest Experiment Station
Maintained in cooperation with University of Minnesota
University Farm, St. Paul 1, Minnesota

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Peeled aspen pulpwood piled along the roadside, a common sight in the northern Lake States where aspen has become the most widely used pulpwood species.

LAKE STATES FOREST EXPERIMENT STATION

ANNUAL REPORT FOR 1951

INTRODUCTION

This 28th Annual Report summarizes the most significant work and findings of the Lake States Forest Experiment Station in 1951. During the year, while our national economy continued to expand and defense materiel had high priority, the necessity of having an abundant timber supply became more evident. To meet this demand, the practice of forestry is spreading throughout the Lake States region. At the same time, however, need for research findings to guide foresters becomes more urgent.

A distinguishing characteristic of the last decade has been a rapid expansion in the use of pulp and paper products. To meet the pulpwood requirements, the Lake States mills import wood from Canada and the western states. From a regional standpoint, it is not wise to depend on such imports when we can grow our supplies at home. The only way we can approach self-sufficiency in pulpwood requirements is by putting emphasis on intensive forestry. It is with this in mind that we devote special attention to the work the Station staff has been doing in the field of "pulpwood forestry."

The first section of this report deals exclusively with growing pulpwood and understanding pulpwood supply problems. But our research program has other phases too. These are touched on briefly in the second section. They include findings in the fields of forest management, fire research, farm forestry, timber survey techniques, and wildlife research. A third section mentions research projects which are planned for 1952.

From time to time, it is helpful to look at our program from the viewpoint of a particular user of research findings. This year we have selected the pulpwood industry because of its economic importance, the complexity of its problems, and the large timber area which is now being managed for pulpwood yields. For nearly half a century, the Lake States pulpwood industry has been expanding and in 1951 at least 10 pulp mills were planning additions to their plants. The region's 46 large pulp mills and 101 paper or paperboard mills employ some 35,000 mill and office workers, have an annual pay roll in excess of 112 million dollars, and turn out products valued at nearly 600 million dollars.

This large and growing industry represents a major user of wood in the Lake States. About 25 percent of the total timber cut in the region each year is used as pulpwood. Annual consumption of pulpwood in recent years has amounted to nearly 2.6 million cords of wood. The pulp mills turn out some 1.5 million tons of wood pulp (about 13 percent of the United States total) and 3.8 million tons of paperboard (about 18 percent of the national output).

The pulp and paper industry of the Lake States is the backbone of the economy of many rural areas and of many well-developed communities. Although some of the pulp mills tend to be concentrated geographically to take advantage of a good water supply, the more typical set-up is a mill located in the heart of a forested area and drawing its wood supply from adjacent forest lands. The large capital investments in these plants and the relative stability of operations give permanency of income and employment to a community and likewise place emphasis on the continuity of an abundant timber supply.

In recent years the pulpwood industry in this region has acquired sizable holdings of forest land, has employed many additional technical foresters, and has contributed to the support of timber resource surveys and forest research. These are all indications of a recognition that along with technological advancements in the manufacture of wood pulp and paper, more effort must be placed on growing timber. Forest research, as will be seen in this report, can be a big help to those who are trying to grow timber economically, to produce the desired species, and to keep forest lands productive.

Whether this major Lake States forest industry will continue to expand, no one can say, but what we are sure of is that for a long, long time there will be an urgent and continuing need for pulpwood. For this reason alone, it is timely to summarize some of the findings of forest research which appraise the timber supply and relate to the growing of pulpwood.

FOREST RESEARCH AS IT RELATES TO THE PULPWOOD INDUSTRY

Some Forestry Problems of the Industry

Determining the Available Timber Supply

Since the end of World War II, some pulp mills have found it increasingly difficult to get the required volume of coniferous wood from nearby forest lands. They are meeting the difficulty by importing wood from Canada and the Rocky Mountains. This, however, is high-cost wood and some of the exporting states and provinces are disposed to restrict future exports. Realizing that there are some idle and partially unproductive areas of forest land here in the Lake States, the industry is taking a close look at the local situation. Before

it can move intelligently on local remedies, the industry must know in considerable detail the extent and condition of forest areas bearing pulpwood species; how much the forest is growing under present conditions; what losses the forest sustains from fire, insects, disease, wind, and cutting; what areas are available for planting; who owns the various types of land; what other industries are using pulpwood species; and what is the aggregate annual drain.

Improved Forest Management

Too often a study of the statistics overlooks the fundamental fact that timber is a renewable resource and that something can be done about declining supplies. This may require only the directing of attention to the availability of certain under-utilized species or going a step further, pointing out the need for reorganizing forest properties so that overmature timber can be harvested first while young stands are growing up. It may involve determination of the adaptability in forest planting of various species to given sites long deforested or it may concern the efficient production of nursery stock for extensive reforestation operations. Doing something about future supply problems may mean coming to grips with difficult and challenging problems such as how to extend the supply of critical species by working out feasible partial-cutting and thinning schedules or regenerating areas long covered with brush through the proper combination of artificial aids and skillful manipulation of forest cover.

Abundance of Hardwood Timber

Utilizing aspen and other hardwoods in place of spruce, pine, and balsam fir is one way to alleviate the short supply of softwood timber. With the allowable cut of aspen alone about twice the present cut, and with over 70 million cords of other hardwoods available for pulpwood from tops, limbs, and cull logs in saw-timber stands and from thinnings in pole stands, the abundance of hardwood timber is a challenge to the entire pulpwood industry. Although basic technological problems retard the shift to use of hardwoods, more needs to be known about the availability of the hardwood supply, the probable harvesting cost, the possibilities of stimulating farm production, and how to manage hardwood stands for pulpwood material.

Economic Aspects

In viewing the long-time aspects of timber supply, the pulpwood industry is confronted with numerous economic problems. In addition to problems of costs and returns in growing and harvesting timber, the industry is concerned with matters of land taxation, income taxes on timber operations, and various types of insurance. It is concerned with legislation relating to importation of wood and pulp, also on questions of freight rates and regulations governing movement of

pulpwood by rail and water. As in other phases of its business, it is interested in statistical data on certain phases of its wood procurement, such as stumpage prices, pulpwood prices, quantities of wood cut, shipped, consumed, stock-piled, etc.

A specific problem of some magnitude is that of making existing timber supplies go farther. The reasons for leaving usable material in the woods are ordinarily related to high costs, low yields, technical difficulties, or a combination of these factors. The solution involves development of more efficient methods for cutting, transporting, and preparing wood as well as adjustments in processing at the mills. It requires labor-saving equipment all along the line. Also, it requires study of the pulp yields from different sizes and grades of material. It calls for better integration of operations for pulp, sawlogs, veneer bolts, etc. And finally, there are the problems of protection from fire, insects, disease, animals, and the matter of losses of wood in storage.

The Station's Work on Pulpwood Problems

The work of the Lake States Station, which can help the pulpwood industry solve its forestry problems, is divided into two main groups: Forest Economics and Forest Management. In the Forest Economics group is centered the Forest Survey work. This is a region-wide project for collecting data on the area, ownership, and condition of forest land, the volume and quality of standing timber, and the annual growth and drain. In the Forest Management group are centered research projects dealing with regeneration, cultural treatment of growing stands, measurement of growth, and prediction of future yields. Noticeably lacking in our program is provision for utilization research. Although basic work in the utilization field is conducted by the Forest Products Laboratory at Madison, Wisconsin, there is need for work in practical application carried on at the woods level.

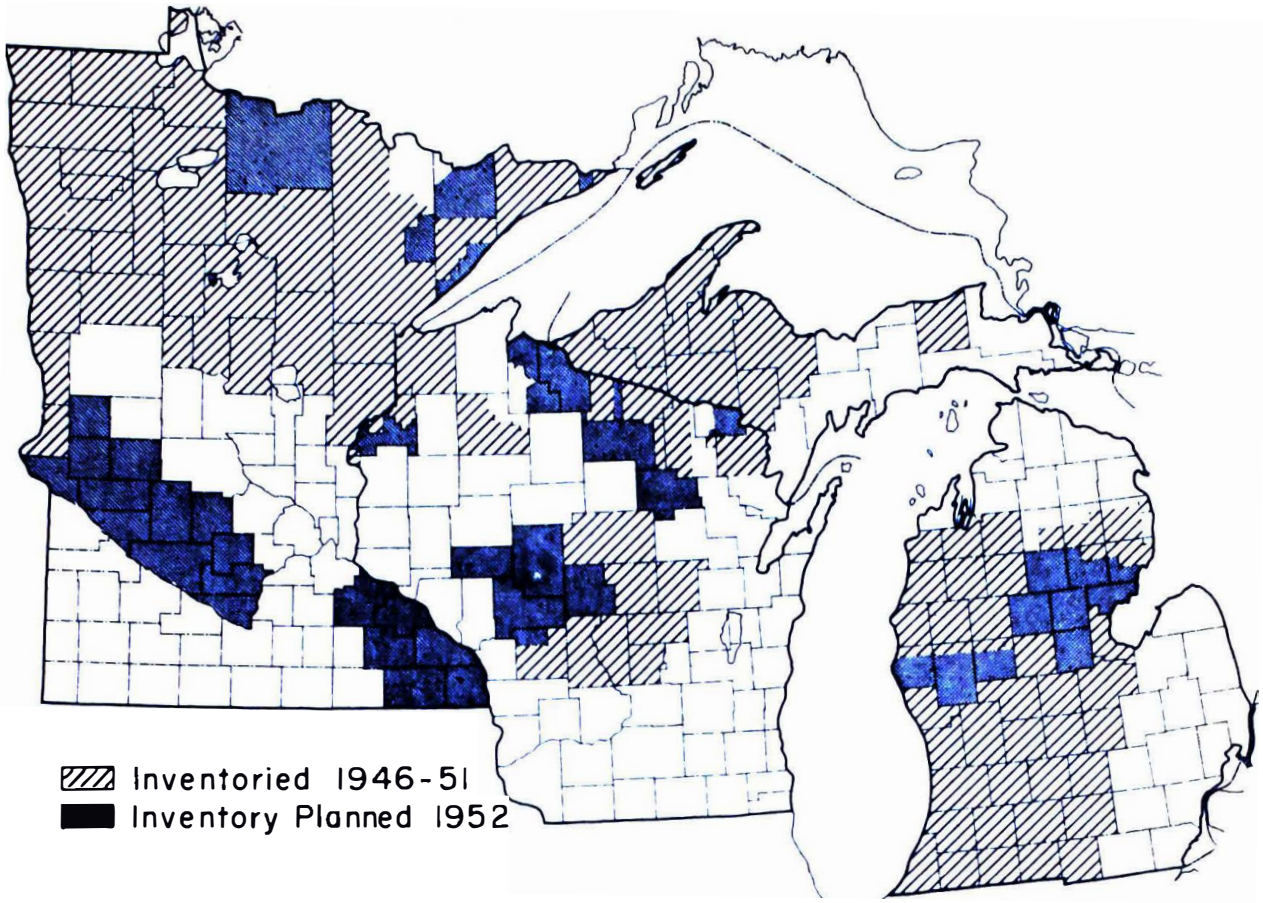
Collecting Data on Supplies - Forest Economics

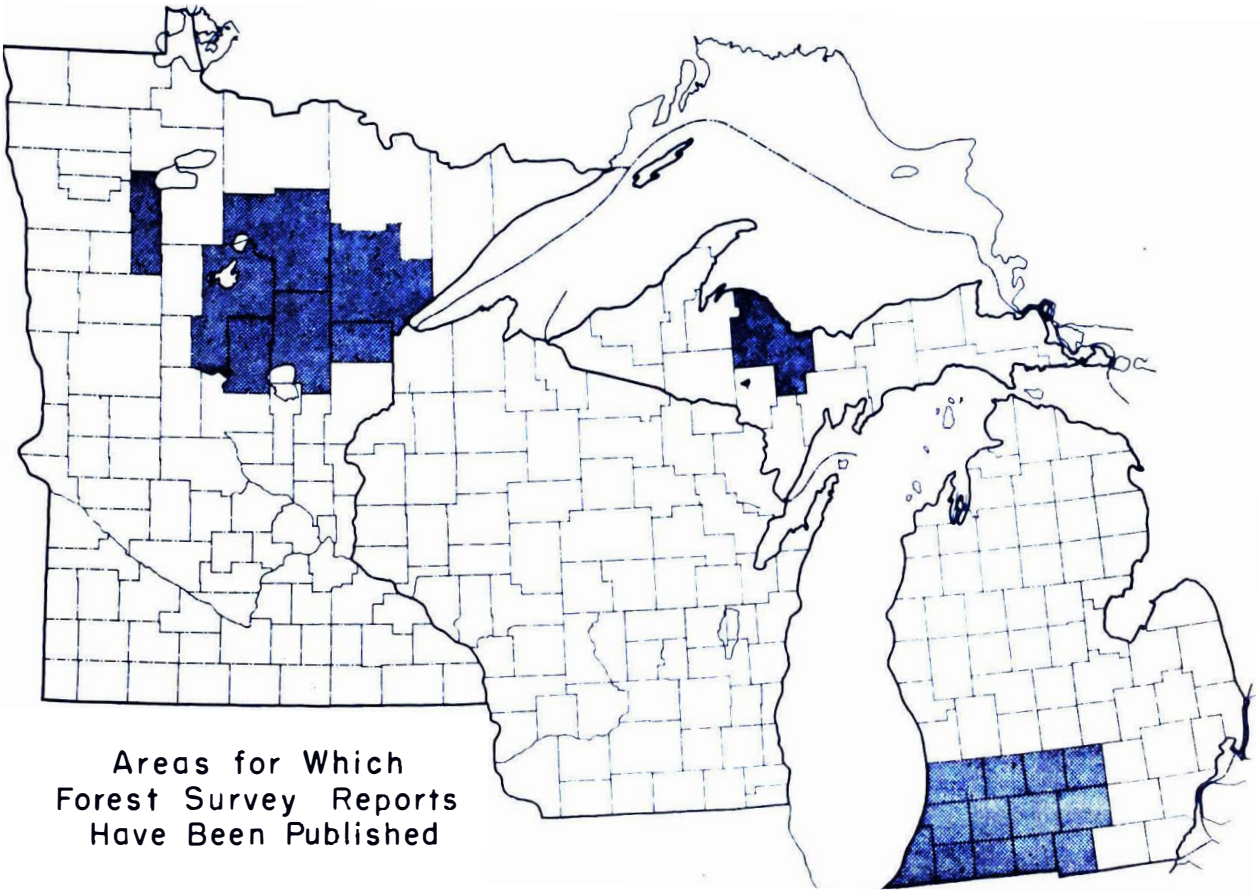
Status of the Forest Survey

The current Forest Survey program in the Lake States, a part of the National Survey of Forest Resources, was begun in 1946. It is a cooperative project designed to yield county-by-county statistics on the forest resources for most of the region.

By the end of 1951, field inventory work had been completed on 13.2 million acres of forest land in Minnesota, 3.8 million acres in Wisconsin, and 9.9 million acres in Michigan. These represent 67 percent of the forest land in Minnesota, 22 percent in Wisconsin, and 52 percent in Michigan. For the region as a whole it is estimated that the job is 48 percent completed. At the current rate of progress it should take about 6 years to finish the job.

PROGRESS OF FOREST SURVEY WORK





Reports have already been released for 7 counties in Minnesota and 14 counties in Michigan.[1/] These reports present a detailed picture of the forest resource situation for each county. They show forest areas by type, size class, and ownership; merchantable volumes and growth and allowable cut by species, size class, and ownership; and the estimated current timber drain. From these data the available pulpwood supply can be determined by species and county. That the pulp and paper industry recognizes the need for such information is demonstrated by the substantial financial aid a number of the companies are providing for this project.

Inventory Findings

The inventories completed in north-central Minnesota and the western half of the Upper Peninsula of Michigan have given some encouraging evidence of increasing growth and a general "thickening up" of young stands. On the other hand, they substantiate the expected decrease of mature and merchantable timber.

In the Central Pine District, Minnesota, density of stocking improved in seedling, sapling, and pole stands of all types, and average volume per acre (all types) increased from 4.7 cords in 1936 to 6.3 cords in 1949. This improvement was reflected also in accelerated growth (.32 cords to .43 cords per acre per year) in sample counties. On the other hand, the acreage of saw-timber stands declined 27 percent and the acreage of softwood types declined 10 percent because of heavy cutting during the interval. The present estimate of allowable cut is double that of 1936 but the increase is all in hardwoods, mostly aspen.

In the west half of the Upper Peninsula of Michigan, density of young growth improved sharply during the 13-year period between surveys and average growth increased 25 percent. The allowable cut did not increase correspondingly because one-third of the saw-timber stands (one-half of the old-growth stands) was liquidated during the period. In this district also, the acreage of softwood types declined even more -- 16 percent.

Trends in Pulpwood Cutting

Pulpwood as pointed out previously makes up about 25 percent of the total cutting drain from our forests; it is exceeded only by sawlog cutting. Consumption of pulpwood by Lake States mills has increased from less than 500,000 cords in 1904 to over 2,400,000 cords in 1950. Because of the rapid growth and the many shifts that have been taking place in pulpwood consumption, the Station has been collecting

1/ Reports for Minnesota may be obtained from the Iron Range Resources and Rehabilitation Commission, Hibbing, Minnesota, and for Michigan from the Department of Conservation, Lansing, Michigan, or from this Station.

detailed consumption data. General statistics are available for the period 1904-1950, and since 1946 detailed statistics have been compiled giving production and source of wood by species and states. These data point to some significant trends in pulpwood production and consumption: (1) They indicate that Canadian imports are declining. In 1950, some 490,000 cords of wood were imported from Canada; in 1941-47, imports averaged over 620,000 cords. A sharp break in Canadian shipments occurred in 1949 when they dropped to 520,000 cords from the 760,000 cords shipped in 1948. Percentage-wise, spruce shipments have declined the most. (2) Western shipments are increasing, although they still make up only a small part of the Lake States pulpwood supply. In 1946, 27,000 cords were imported from western states; in 1950, 65,000 cords. Seventy-five percent of this wood was lodgepole pine, and most of it came from Montana. (3) More and more aspen and pine are being used as pulpwood. In 1936, only 125,000 cords of aspen were used by Lake States pulp mills; while average consumption for 1946-50 was 640,000 cords. The same situation prevails in pine. From 270,000 cords in 1936, consumption of pine jumped to an average of 530,000 cords in the 1946-50 period. In the same period there has been only a slight change in the consumption of spruce and balsam fir. (4) Hemlock is becoming less important as a pulpwood species. In the period 1941-1945, the average annual cut of hemlock was 340,000 cords, while in the 1946-1950 period only 185,000 cords were cut. The largest recorded cut of hemlock pulpwood was in 1944 when some 400,000 cords were produced in the Lake States while the smallest cut was 110,000 cords in 1949. Part of this changing picture is caused by liquidation of old-growth hemlock stands and by the stiff competition the sawmill industry gives for logs. In 1946, over 60 million board feet of hemlock logs were shipped to local pulp mills, but by 1950 these shipments had declined to about 20 million feet, a decrease of nearly 70 percent.

Research in Growing Pulpwood - Forest Management

To grow pulpwood it is necessary to know how to establish new stands, how to care for young stands, how to improve immature stands, what yields may be expected at maturity, and how to harvest mature timber.

Establishing a New Stand

How to establish a new stand of timber at the time the old one is cut or after a period of deforestation has long been an active project of the Station. Studies of natural reproduction in pine were started in 1926, on spruce and aspen in the mid-thirties, and on balsam fir within the last two years. Also, during the past 25 years, the Station has devoted much emphasis to various phases of reforestation.

Mechanical Aids to Natural Reproduction.--If successive crops of pulpwood are to be grown, reproduction should be obtained simultaneously with the removal of the old stand, and unproductive areas should

be restocked promptly. It is not enough to depend on nature; frequently man must lend a hand. For example, jack pine often does not regenerate well after cutting, but mechanical ground scarification with a disk plow can help to produce well-stocked stands as illustrated by a recent examination of large-scale field trials in Minnesota. In this area where rank growth of hazel brush makes regeneration notoriously difficult, overmature jack pine stands 80 to 120 years old were clear-cut during the winter of 1939-40 and 1940-41. Slash was bunched progressively during logging. In the spring following cutting, the area between slash piles was cross-disked with Athens disk plows exposing mineral soil on about 60 percent of the surface. Cone-bearing slash was immediately scattered over the bare soil. Remeasurements 10 years later by the Headwaters Forest Research Center show that 70 percent of the quadrats are stocked with over 3,000 trees per acre averaging about 8 feet in height.

The possibility of using the disking technique as a relatively cheap means of stimulating aspen suckers on understocked areas to be managed for aspen production was first pointed out by the Station in 1946 in a preliminary test on the Pike Bay Experimental Forest in Minnesota. In 1950 more disking tests were made on aspen. Among them was a cooperative study with Northern Paper Mills at Amasa, Michigan, which gave highly satisfactory initial results. Another was made on three areas in cooperation with the Rhinelander Paper Company, and produced 4,600, 8,000, and 16,300 aspen sprouts per acre respectively.

Disking was tried also in a hardwood type in 1948, when a scattered stand of second-growth hardwoods was disked on the Argonne Experimental Forest in Wisconsin in order to prepare a suitable seedbed for reproduction. The following year a tremendous crop of seedlings, chiefly sugar maple, came up.

Another test involved disking in August 1950 of an open stand primarily composed of balsam fir and paper birch trees about 10-percent stocked with saplings and poles, and with only a few hundred balsam fir seedlings per acre. At the time of disking there was a bumper crop of balsam fir and paper birch seed on the trees. The newly prepared seedbed resulted in a tremendous first-year crop of natural seedlings on disked portions of the tract, as shown below:

Species	Disked quadrats (1/4000-acre) stocked	Seedlings per acre: Disked strips	Seedlings per acre: Total area
	Percent	Number	Number
Paper birch	82.5	288,600	173,160
Balsam fir	57.5	14,100	8,460
Red maple	32.5	3,900	2,340
Aspen	12.5	1,200	720
Spruce	2.5	100	60
All trees	95.0	307,900	184,740

Even assuming very heavy mortality in the future, it appears that a fairly well-stocked mixed stand of pulpwood trees can develop.

Granted an adequate supply of viable seed, 40 to 60 percent of the surface in recently exposed mineral soil, and abundant rainfall in the first two growing seasons following treatment, disking can provide adequate stand regeneration at a cost only 20 to 25 percent that of planting.

Reproduction Survey in Coniferous Swamps.--A forest research program in coniferous swamps was initiated in the Upper Peninsula of Michigan last year with a survey of cuttings. The objective of this survey is to determine what kind of stand has resulted from different kinds of cutting on different swamp types and sites. The findings, which will be available in 1952, can be helpful in directing future research in the management of the potentially valuable swamp forests; also in evaluating the present condition of sample areas.

The field work for this survey, completed during 1951, assembled data from 2,600 milacre plots distributed over 65 swamp forest cuttings. Cooperating with the Station in the project were the Bonifas Lumber Company, Escanaba Paper Company, Northern Paper Mills, Cleveland-Cliffs Iron Company, the Michigan Department of Conservation, and the Ottawa and Upper Michigan National Forests.

While many swamp forests have been cut over in the Upper Peninsula, only those were examined for which the conditions at the time of cutting were known or could be closely reconstructed. Records and lands of forestry agencies, companies, and timber operators were checked to gather this information.

Nursery Work, Planting, Seed, Hybrids.--A sizable program of nursery work was carried on by the Station from 1937-1942 in cooperation with Region 9, U. S. Forest Service, emphasizing density of sowing, root pruning, methods of sowing, and soil fertility. Later, chemical weed-control studies were initiated. Forest planting research, begun in 1924, culminated in 1950 with the issuance of a general bulletin incorporating results. A companion publication on nursery practice is now being written in cooperation with Region 9. Results of forest seed research, begun at the Station in 1928, formed a substantial part of the Woody Plant Seed Manual, distributed in 1950.

Hybrid pine stock (crosses between jack pine and lodgepole pine and others between eastern white pine and western white pine) developed by the California Forest Experiment Station at its tree-breeding institute is being grown and will be ready for a field test in the next two years. A new test of hybrid poplars was installed by the American Box Board Company in cooperation with the Station.

Disking a brushy area with Athens-type disk and crawler tractor. This practice may be used to stimulate aspen suckering, to prepare a seedbed for natural or artificial reseeding, or to prepare the ground for planting.

A recent finding of practical value is proof that seeds from old cones of jack pine can produce trees as good as those from new cones. The following data based on a study of 1,600 jack pine 1-1 transplants spaced 5 x 5 feet shows that after 14 years there is little or no difference in growth when age of seed is the variable:

Age of seed when sown (1935) (Years)	14 years' growth	
	Average total height	Average d.b.h.
	Feet	Inches
1	16.5	2.2
2	16.4	2.3
3-4	16.3	2.2
5+	16.5	2.3

Care of Young Stands

Nature, in providing for the continuance of a forest cover, often does too good a job. As a result, some stands are too thick for good growth; others may be mixed or overtopped with too many of the less desirable species. Brush at times becomes a serious competitor of the forest trees. In short, natural stands (and planted ones as well) need care for best development. The Station recognized this problem back in 1929 when it started thinning studies in jack pine and aspen, and during the 1930's when it carried on a great deal of work in release of natural and planted stands from brush and other competition. A few years ago mechanical thinning with power equipment was tested in cooperation with Mosinee Paper Mills and the Nekoosa-Edwards Paper Company. Most recently the possibility of using chemicals to kill undesirable cover has been tested on a considerable scale.

Chemical Control of Scrub Oak and Other Woody Plants.--Scrub oak and other inferior tree growth present a problem on many thousands of acres of pulpwood forests in the Lake States. Such cover suppresses natural jack pine and overtops planted jack or red pine to the great detriment of growth of the desirable conifers. The undesirable trees may be removed by hand cutting, but the labor cost of such work is usually prohibitive. Accordingly, the Station has been testing various chemicals and methods of application that have been advocated for killing unmerchantable hardwoods.

A study applying ammonium sulfamate to notches cut near the base of scrub oak trees indicates good control can be attained at a reasonable cost in Wisconsin. The chemical is applied in crystal form at the rate of a slightly heaped tablespoon per face cut. Cuts were made horizontally near the base of the tree at intervals of 6 inches on the circumference. Cost of application was $2.11 per 100 trees. Complete mortality without any basal resprouting was observed on 86.3 percent of all trees two years after treatment. Jack pine reproduction 1 to 3 feet tall in the understory doubled its annual height growth in the two years following treatment. No damage to the pine occurred from the chemical treatment of oak.

Ammonium sulfamate has also been used for the control of scrub oak, aspen, and red maple in the Lower Peninsula of Michigan. Here it has produced effective top kills when applied in crystalline form to notches cut in the base of the trees or on cut stumps. Except for higher costs of application as compared to the ax method, it appears to be an effective herbicide for controlling many woody plants.

Low volatile esters of 2,4-D, 2,4,5-T, and combinations of the two also have been tested for control of woody plants in lower Michigan. Research during 1951 was aimed largely at trying to reduce the cost of application of chemical herbicides by seeking minimum dosages and improved techniques. One method which proved very effective included the application of a water emulsion of 2,4,5-T to frills cut around the tree with an ax at a convenient chopping height. When applied during the growing season, 8 pounds of 2,4,5-T acid equivalent per 100 gallons of water gave effective top kills. During the dormant season, however, as much as 40 pounds of 2,4,5-T acid per 100 gallons of water failed to kill the same species, but only 4 pounds of 2,4,5-T to 100 gallons of diesel oil was effective. Regardless of season, basal sprays using a 2-percent solution (by volume) of 2,4-D, 2,4,5-T, and a 50-50 mixture of each in diesel oil gave satisfactory top kills when applied to a height of 4 feet on scrub oak, aspen, and red maple. However, when the trees were sprayed to a height of 1 or 2 feet, only the 2,4,5-T gave an effective and consistent top kill. The most reliable year-around concentration to use appears to be 12 pounds of 2,4,5-T acid per 100 gallons of diesel oil.

The effect of the chemical herbicides on subsequent sprouting of trees treated has not yet been fully determined for Lake States conditions. Many of the scrub oaks treated in lower Michigan by the frill method sprouted during the first growing season, which is contrary to results reported from the southeast. However, the same species treated with basal sprays and ammonium sulfamate crystals did not sprout the first year. Observations will be continued for several seasons to determine the amount and time of resprouting of chemically treated trees.

Christmas Tree Harvest Reduces Investment in Pulp Stand.--High net returns through partial cuttings for Christmas trees are being obtained from some plantations sooner than was anticipated. This is illustrated by a red pine plantation on the Lower Michigan National Forest which was established in the fall of 1941 with 1,200 trees per acre on a good old-field site. Survival was excellent. In the fall of 1950 an average of 89 trees per acre was sold for Christmas trees at $48.21 per acre and over 1,000 trees per acre remained to provide future cuts for pulpwood and other products. After deducting $1.38 for sale administration, $10.55 for planting, and $0.90 for fire protection, there was a net return of $35.38 per acre. Not all red pine plantations can be expected to produce Christmas trees from early cuts. Dry sites frequently produce off-color trees and on the best sites the distance between whorls is too great for well-formed trees. In many plantations, however, early "selective" cuttings for Christmas trees offer opportunities for completely liquidating the initial investment without damaging the future productivity of the stand.

Stand Density and the Development of Young Jack Pine.--What effect does stand density have on the development of young jack pine stands? To shed light on this question, an experimental plantation was set out in 1941 on the Manistee National Forest in Michigan in which spacings of $1\frac{1}{2}$ x $1\frac{1}{2}$, 3 x 3, 5 x 5, 7 x 7, and 9 x 9 feet were used. At the end of 10 years, a spacing of slightly greater than 5 x 5 or about 1,500 trees per acre looks best for the site in question. The minimum acceptable stocking appears to be about 800 trees per acre; 500 trees per acre is definitely too few for satisfactory development. While jack pine plantations seldom will be planted closer than 5 x 5 feet, natural reproduction and direct seedings frequently approach or exceed the densest stocking tested. The results should, therefore, be valuable in guiding the handling of either natural or artificial regeneration under similar soil and site conditions.

Improvement of Second Growth

Commercial thinnings and improvement cuttings in merchantable second-growth afford a large potential supply of pulpwood, much of it from material that would otherwise be wasted through natural mortality or unused in sawlog operations. As early as 1927, the Station initiated experimental thinnings in jack pine-red pine stands in Minnesota--long before there was a market for pulpwood thinnings. Further commercial thinnings were started in jack pine in 1940. Last year experimental commercial thinnings and partial cuttings were started in aspen-balsam fir stands of intermediate age with a view toward a final cut for pulpwood about 10 or 15 years hence.

Plantation Thinnings a New Pulpwood Supply.--A new source of pulpwood is developing in the Lake States in the form of thinnings from almost one million acres of red pine and jack pine plantations, most of which were planted in the "thirties," although a few are now about 40 years of age. Some of the older plantations in lower Michigan have been thinned commercially for pulpwood since 1945, and large areas of later plantations are developing rapidly to that stage.

The Station has a number of studies under way to determine the most desirable form of plantation management. During 1951 the Lower Peninsula Forest Research Center, in cooperation with the Division of Forestry of the Michigan Department of Conservation, made thinnings of different intensities and methods in a 39-year-old red pine plantation on the Higgins Lake State Forest. A similar thinning was started on the Lower Michigan National Forest in a 34-year-old red pine plantation. Both plantations are growing on poor sites in spite of which the thinnings have harvested from 2 to 10 cords per acre, with the expectation of further thinnings every 5 to 10 years for at least 40 to 50 years.

Prompt Salvage Increases Yields.--That salvage operations have an important part in forest management is illustrated by results of a study at the Argonne Experimental Forest in northeastern Wisconsin. Two years ago a heavy wind blew down some 200 million board feet of timber on about 15 million acres of forest land in northern Wisconsin. Blowdown was spotty and caused much breakage to fallen trees. On the 6,500-acre Argonne Forest, salvage operations were initiated on a commercial basis and in 2 years some 524 cords of pulpwood and 12 M board feet of logs were obtained. This material had a stumpage value of about $1,700, or 26 cents per acre. Extension of the road system made enough additional area accessible to permit salvage of 276 cords out of the total.

This short-term case study shows that salvaging material which would otherwise be a total loss increases the timber yield and that an intensive road system is highly important in facilitating salvage.

Yields and Management of Older Timber

A knowledge of yield is necessary for intelligent management of a forest property. So one of the first projects undertaken by the Station, in cooperation with the Wisconsin Conservation Department and other agencies, was a study of the yields of fully stocked jack pine stands, which was published in 1929. Similar tables were also prepared for white pine, aspen, black spruce, red pine, and other forest types. The latest yield study dealt with balsam fir in stands of various densities and mixtures.

Yields and Management of Balsam Fir.--In view of the increasing importance of balsam fir to the pulp and paper industry, the Station has issued two reports dealing with this species--one on growth and yield on upland sites in the Lake States, the other a summary of present knowledge with special reference to Minnesota conditions. The yield tables are the result of a study made in cooperation with most of the forestry agencies and industries in the Lake States. The tables show that this species will produce gross volumes of about 30 cords per acre in 60 years when grown in stands of average density on average upland sites.

Balsam fir is the dominant species on about 3½ million acres in the Lake States, and due to its ability to succeed less tolerant trees, the area is rapidly increasing. Consumption of balsam fir for pulpwood has almost doubled since 1944, so that this species is now fourth in importance of Lake States pulping woods. As the supply of spruce continues to dwindle, the use of balsam fir for pulpwood seems bound to increase. It is, therefore, important to learn how to manage balsam fir lands so as to maintain and even increase the production of this valuable wood.

With this in mind, the Station has put in a balsam fir cutting experiment on the Chippewa National Forest testing methods ranging from commercial clear cutting (16.9 cords per acre removed) to light selection cutting (4.8 cords cut). Plots will be measured at regular intervals to determine amount of growth and mortality. The experiment will be repeated elsewhere.

Black Spruce Management.--Of special concern to many pulp and paper companies and land managers is the prospect of a diminishing supply of spruce. This situation gives high priority to research in the management of black spruce, particularly in the extensive spruce swamps of northern Minnesota.

The Station's work in this type is concentrated at the Headwaters Branch. On the Big Falls Experimental Forest, an area of state land which is operated in cooperation with the Minnesota Forest Service, a comprehensive study has been established which includes six cutting methods and an uncut check. Four of the treatments involve forms of even-age management: (1) successive clear-cuttings in strips, (2) successive clear-cuttings in patches, (3) shelterwood cutting, and (4) light partial cutting to carry the stand as long as possible. The other two treatments are attempts to develop and manage all-age stands: (1) by individual tree selection, and (2) by group selection. Check areas are included to follow growth and mortality in unmanaged stands and as a base from which to gauge results of the treatments.

Coupled with this long-term testing of cutting methods, the study has several short-term aspects such as the establishment and development of reproduction under various stocking conditions, effect of cutting method on advance growth, and some evaluation of different factors of site and of tree class.

To maintain supplies of high-grade spruce pulpwood until such time as yields can be obtained from second-growth stands requires conservative handling of present mature stands of black spruce. Classification of trees as to vigor and position in the stand can aid in determining treatment and in marking for partial cutting. Recently analyzed growth records on over 1,100 sample trees in a study established in 1941 in cooperation with the Minnesota Forest Service and the Minnesota and

Ontario Paper Company showed marked relationships between tree class and growth on three different stands. Good-vigor trees grew well whether dominant or intermediate, and poor-vigor trees were poor growers regardless of position in the stand.

OTHER RESEARCH WORK OF THE STATION

While many of the Station's research findings are especially useful to the pulpwood industry, others are of greater interest to those who seek information on fire protection, farm forestry, forest survey techniques, sawlog forestry, site evaluation, or wildlife management. Some recent results of Station studies in these fields follow.

Fire Protection

In cooperation with the Wisconsin Conservation Department, the Station completed a study of forest fires and forest-fire control and an analysis of Wisconsin's present forest-fire problem. A report on the study, to be published by the State, covers these main points: (1) the history of forest fires, fire control, and fire-control legislation in Wisconsin; (2) progress in fire control which, since 1927, has reduced the number of fires per year from 2,500 to 1,500, and their average size from 200 to less than 10 acres; (3) the causes of fires, the most important of which have been smokers, 31 percent; debris burning, 20 percent; railroad operation, 15 percent; and incendiarism, 13 percent; (4) occurrence of fires, about half of which originate in the spring, one third in the summer, and the balance in the fall; (5) the relative severity of burning conditions between April 1 and October 31, which by number of days and burning index classes have averaged 54 safe, 40 very low, 40 low, 34 moderate, 24 high, 17 very high, and 5 extreme; (6) State expenditures for fire protection which have risen from 1.22 cents per acre in 1929 to 6.38 cents per acre per year (inflation has cut the relative value of the latter expenditure nearly in half); (7) the cost of fire control which is provided 72 percent by the State, 27 percent by the Federal Government, and 1 percent by the counties.

The report points out that Wisconsin has come a long way in solving its forest fire problems, but the threat of forest fires remains and there can be no let up in protection effort if forest fires are to be kept under control. On the basis of the present record, it would appear that protection in Wisconsin is reasonably adequate except for the southern part of the state. There is still need, however, to further reduce the number and size of large fires since these are responsible for the bulk of loss and suppression costs. To this end, intensification of effort in the extensive protection districts and provision for the more efficient handling of large fires is called for.

The report concludes that Wisconsin owes much of its success in fire control to sound legislation, adequate financing, and progressive leadership. Its people can well be proud of what they have accomplished.

Farm Forestry

Farmers own one-fourth of the forest land in the Lake States, much of it of high potential production, yet most of it neglected or abused. One way to improve this situation is to show farmers that their woods are valuable if handled properly. Recent findings of the Station provide information which shows that farm woods can be profitable.

Farm Woodland Management

Typical farm woodland tracts of 40 acres have been managed by the Station for 5 years in the Upper Peninsula of Michigan and northeastern Wisconsin. Nine Timber Harvest Forests are handled in a similar manner by the State Conservation Department and the State Extension Forester in cooperation with the Station in Wisconsin.

After five annual cuts removing volumes about equivalent to growth, and mostly in poorer quality trees, the farm forestry forties in upper Michigan and northeastern Wisconsin now contain timber of greater volume and better quality than they did at the start. What is more, the material cut has yielded net returns of $1.10 to $1.60 per man-hour to the operators. Indications are that about 350 acres of second-growth hardwood timber in upper Michigan can provide one man-year of labor at an annual return of $7.50 per acre or $2,625 annually.

More evidence that improvement cuttings in farm wood lots can combine good silviculture and good economics was provided by two cuttings made on the Dundee Timber Harvest Forest in Fond du Lac County, Wisconsin, in 1947 and 1948. The stand which was logged consisted of a 17.0-acre block of old-growth trees scattered through well-stocked second-growth of saplings, poles, and small sawlog timber. Most of the volume harvested came from the larger, more-defective trees, but, surprisingly enough, the 20 M board feet, gross tree scale, of material cut yielded 13,280 board feet, net log scale, of salable products. Moreover, the quality of the material which remained after cull sections, butt-offs, rotten tops, etc., had been eliminated was excellent; 80 percent of the total volume of all logs recovered from the two improvement cuttings were of No. 1 or No. 2 grades.

Farm Fence Studies

To develop an economical fence post of native wood is the object of a study begun in 1948 in cooperation with the Minnesota Agricultural Experiment Station. Emphasis during 1951 was on preservative treatment of posts by the vacuum process and methods of driving large corner, end, and approach posts.

pilot vacuum treating unit was assembled at the Cloquet Forest Experiment Station, and preliminary test runs with seasoned jack pine posts indicate excellent treatment can be obtained with a treating cycle of less than one hour.

In a test an average of 25 posts per hour were driven with a two-man crew in 2 miles of fence which included 22 corner and end constructions and end and gate posts for 8 gates. The posts driven ranged up to a maximum of 9 inches in diameter at the small end and 8 feet long.

Improved Forest Survey Techniques

An important project of the Station is to make a complete inventory of the forest resources of the Lake States. Obviously, it is impractical to examine each acre of forest land out of the 50,000,000 in the region. So it is necessary to use sampling methods which will furnish data of satisfactory accuracy at a reasonable cost. For this reason, any developments which will provide greater accuracy or permit less intensive sampling are valuable. Several improved techniques have been developed by the Station during 1951.

Estimating Growth

Although growth can be estimated by cruising methods, better information on growth, defect, and mortality can be obtained more cheaply and quickly from permanent plots. For this reason, a large number of permanent 1/5-acre plots were established by the Forest Survey in 1951. Future remeasurements will provide accurate data on the relationships between amount of growing stock and resulting growth; between condition of the individual tree and its increase in size; between various methods of cutting and wood increment; and between local site differences and growth.

Better Volume Tables

The Station is preparing a compact series of new volume tables compiled for the Lake States region. These tables are based on thousands of measurements obtained in this region during the past 25 years. Some of the tables have been in use for several years and have been found generally satisfactory by industry and various public forest agencies.

The new tables further the present trend which is toward the use of fewer tables which can be modified or adjusted on the basis of differences in stand composition and the factors affecting both total and utilizable volume of tallied trees. Such an approach is not only more convenient for field application but also more accurate than the use of many common species tables since it requires the appraisal of the characteristics of the timber to which the table is to be applied.

Estimating Allowable Cut on the Ground

The portion of the present growing stock that should be cut annually in regular logging operations while approaching sustained yield, or allowable cut, in the past has been estimated largely from office calculations. Beginning in 1951, however, Forest Survey inventory crews have estimated allowable cut on the ground for partial cuts in mature uneven-aged stands and for thinnings, improvement cuts, and salvage operations in all stands. Two main factors considered are: (1) the silvicultural requirements of the forest type, and (2) operability of the stand.

Field crews are furnished general guides to help them decide on the most desirable rotations, cutting cycles, levels of growing stock, and cutting methods for each type. Often, however, they must use their best judgment in modifying these guides to fit a particular stand or area.

The same is true of operability which usually is based on experience on nearby forests where good silvicultural practices are in effect. Lacking other criteria, a minimum of 3 cords of pulpwood, or 1,500 board feet of sawlogs, will be considered operable (1 cord or its equivalent in farm woodlands). Judgment must be exercised here, too. The more inaccessible a tract, the larger the timber volume or the greater the value to be operable. Both volume per acre and total volume to be cut must be considered in determining operability in order to have a realistic appraisal of the amount of merchantable timber available for commercial logging operations.

Estimating Fuel-wood Drain

One of the weakest links in calculating timber drain in the Lake States is the lack of accurate fuel-wood production figures. To overcome this deficiency, Forest Survey cooperators in 1951 began to gather fuel-wood data in each county where the survey crews were working by means of the following sampling scheme:

1. Routes of travel are selected that traverse the county twice, once in a north and south direction and once in an east and west direction. The route is jogged or offset along lines of travel so that mileage on different classes of roads is proportional to the total mileage of such roads in the county.

2. The routes of travel are plotted on a map, and field men contact a farmer or other rural resident every 2 miles along the route.

3. If the respondent does not produce fuel wood from his own or rented lands, a notation is made of this on the form. For those reporting fuel wood, the amount produced for home use as well as that sold to others is recorded. Fuel wood made from slabwood, edgings, veneer cores, discarded railroad ties, etc., is not recorded as production. Residents of cities and towns are omitted from the sample.

4. Each bona fide contact made in the field is plotted and numbered on the field map.

5. When the field work is completed, fuel-wood figures are summed up and averaged to determine the number of cords or fractions of cords of fuel wood produced per acre of woodland. Figures on total acreage of forested lands by ownership are available from the Forest Survey data.

6. Large private owners and public agencies owning appreciable acreages of land in the county are contacted to obtain information on the amount of fuel wood and other forest products cut from their lands. Fuel wood produced on such lands is added to farm production to get over-all county production.

Other Forest Management Studies

In addition to the forest management studies directly applicable to pulpwood forestry, during 1951 the Station also carried on research on logging damage, the applicability of Forest Products Laboratory log grades to second-growth hardwoods, oak-site evaluation, and costs of pruning red pine.

Logging Damage in Partially Cut Hardwoods

Under any type of partial cutting in northern hardwoods a certain number of trees that are left for future growth will be injured in felling, skidding, and loading operations. This damage appears as broken branches in the tree crowns and stem or butt scars from peeling the bark through mechanical injury.

In 1951 the Station, in cooperation with the University of Michigan School of Natural Resources, began a basic study which will give information on the seriousness of this damage to the future yield and quality of the residual trees. The hardwood study plots and cuttings established between 1926 and 1940 at the Upper Peninsula Experimental Forest at Dukes, Michigan, provide cutting records and tree damage information which are being checked for occurrence of rot in logging scars, the presence of disease organisms, and the rate of spread of defect. Ultimately, a method of appraising tree risk on the basis of logging damage may be developed for use by forest managers and timber markers.

Present plans provide for the field work to continue during the summer of 1952 and 1953.

Forest Products Laboratory Log Grades Satisfactory for Second-growth Wisconsin Hardwoods

The logs from an improvement cut in second-growth hardwoods in northern Wisconsin were graded according to the log-grade rules developed by the Forest Products Laboratory in Madison,[27] and followed through a mill to get the actual lumber-grade recovery. It was found that the lumber-grade yield tables for these log grades successfully estimated the lumber values produced to within 10 percent for the total cut of both sugar maple and yellow birch as shown below:

Table 1.--Comparison of estimated versus actual value of graded logs

Log grade	Volume, green lumber tally		Value of lumber per M bd. ft.		Error of estimated value per M bd. ft.	
			Actual	Estimated		
	Bd.ft.	Pct.	Dollars	Dollars	Pct.	Dollars
SUGAR MAPLE						
1	1,695	6.0	105.38	116.61	+10.7	+11.23
2	10,069	35.6	83.55	83.20	- 0.4	- 0.35
3	16,502	58.4	59.04	62.75	+ 6.3	+ 3.71
Total	28,266	100.0	70.55	73.26	+ 3.8	+ 2.71
YELLOW BIRCH						
1	1,851	13.8	120.96	133.86	+10.7	+12.90
2	5,311	39.8	107.65	92.56	-14.0	-15.09
3	6,199	46.4	71.16	62.25	-12.5	- 8.91
Total	13,361	100.0	92.55	84.22	- 9.0	- 8.33

[27] Hardwood Log Grades for Standard Lumber, Proposals and Results, March 1949, Report No. D1737.

Judging Oak Sites

Combinations of soil texture and topography, as they affect soil moisture, are the principal site factors influencing the growth and yield of red and black oaks in southern Michigan according to a cooperative study completed by the Station and Michigan State College. The clay content of the soil is usually related directly to the amount of moisture retained in the soil. The importance of the clay content where the influence of slope and topographic positions are negligible, as on flat land, is illustrated in the following table:

Soil texture:	Yield of average dominant and codominant tree at 40 years		60 years		80 years	
	Cu.ft.[4]	Bd.ft.[5]	Cu.ft.	Bd.ft.	Cu.ft.	Bd.ft.
Heavy[1]	19	56	33	105	56	210
Medium[2]	13	28	18	45	26	75
Light[3]	8		12	24	15	32

When these same textured soils occur on slopes, the position on the slope and degree of slope also affect the yields of oak as shown below:

Soil texture	Yield of average dominant and codominant tree at 60 years - steep slope (30%+)					
	Upper slopes		Middle slopes		Lower slopes	
	Cu.ft.[4]	Bd.ft.[5]	Cu.ft.	Bd.ft.	Cu.ft.	Bd.ft.
Heavy[1]	19	45	24	70	24	70
Medium[2]	15	28	19	45	24	70
Light[3]	9	16	15	28	24	70

1/ Soils which range from clay to moderately heavy loams throughout the profile.

2/ Generally sandy in the surface layers; the subsurface is also sandy, but has a cemented layer of small amounts of clay at 12 to 20 inches from the surface.

3/ Sandy throughout the entire profile.

4/ Total volume of stem less bark. USDA Bulletin No. 560.

5/ International 1/4-inch rule. Form Class 78.

The degree of slope has considerable effect on surface and subsurface drainage and the position on the slope determines whether soil moisture is lost or gained as a result of drainage. Thus, oak yields are low on light sandy soils and upper slopes where moisture can drain away. However, on lower slopes where drainage is impeded and the soil moisture can be replenished from above, the yields of oak are high regardless of the soil texture.

Costs of Pruning Red Pine

Nearly half of the plantations in the Lake States are composed of red pine. In the future this species will provide an ever-increasing proportion of the locally grown pine saw timber. Natural pruning is slow, and it is apparent that lumber produced from almost all red pine plantations will be knotty unless very long rotations are followed or artificial pruning is practiced.

In order to obtain costs that can be used to estimate the economic possibilities of pruning, the Station in 1950 collected data on the costs of pruning red pine trees in plantations ranging from 10 to 40 feet in height. The total time required to prune trees to 17 feet with hand saws and pole saws averaged 7 to 10 minutes per tree in well-stocked plantations and over 12 minutes per tree in an open-grown stand. Total pruning time fluctuated considerably because of the many variables involved, which include: size of limbs, number of whorls, number of limbs per whorl, condition of limbs (whether alive or dead), type and condition of tools, terrain, weather, and skill and incentive of labor.

The cost per tree must be converted to cost per M feet board measure of clear lumber that is produced. The sample calculation shown below illustrates the probable cost (over and above other costs) of producing high-grade lumber by pruning when the trees pruned are 5 inches in diameter at 20 years of age, growth is 2 inches per decade from 20 to 100 years and 1.5 inches per decade from 100 to 120 years, and the initial cost of pruning per tree is $0.25.

Rotation age (Years)	Cost of pruning per M bd.ft. of clear lumber produced when interest rate is -		
	5 percent	3 percent	:
	Dollars	Dollars	Dollars
60	38.20	18.50	6.10
80	43.90	14.40	2.60
100	67.00	15.00	1.50
120	128.50	19.60	1.10

It is apparent that with the higher interest rates pruning probably will not be profitable, but with low interest rates pruning red pine will be worth while if the present premium on clear lumber continues.

Forest Wildlife Research

(Conducted by the Fish and Wildlife Service in cooperation with the Forest Service)

During 1951 forest wildlife research was directed mainly toward (1) an appraisal of the results of simulating snowshoe hare and deer damage to coniferous trees, (2) a study of range recovery in exclosures for deer and snowshoe hares, (3) an appraisal of beaver management information on the Grand Portage Indian Reservation, (4) an analysis of the data pertaining to the Necedah Refuge deer irruption, and (5) to the collection of deer management information during the special open seasons on the Tamarac and Mud Lake National Wildlife Refuges.

Effect of Simulated Hare and Deer Damage to Conifers

The result of clipping one inch of the terminal shoots of jack pine, red pine, white pine, and white spruce planting stock has a marked effect on growth and survival, as shown by a study in which 2-0 jack pine, 2-0 and 2-1 red pine, 2-0 and 2-1 white pine, and 2-2 white spruce trees were clipped once, twice, three times, and twice in alternate years. Based on sensitivity to clipping, the species rated in this order: red pine, white pine, jack pine, and white spruce. Transplants withstood clipping better than seedlings which, with fewer needles left after clipping, have less ability to survive.

Effect of White-tailed Deer and Snowshoe Hares on Range Recovery

Sixteen exclosures for deer and snowshoe hares have been established by the Station, the national forests, and the U. S. Fish and Wildlife Service to obtain information on the recovery of vegetation when browsing is prevented. Four are located on the Lower Michigan National Forest, two are on the Chippewa National Forest, and ten are on the Superior National Forest. Most of the exclosures were built in recent years, although two of the oldest ones were constructed in 1938. Cover types represented include: 10 in mixed-cedar swamps, 1 in a virgin white pine stand, 3 in jack pine plantations, 1 in a white pine plantation, and 1 in a mixed red pine and white spruce plantation. Findings will be summarized in future annual reports.

Beaver Management

The Grand Portage Indian Reservation in northeastern Minnesota was closed to beaver trapping and stocked with beavers in 1943. An airplane check on the population showed it had increased to 26

active colonies in 1946 and by 1951 it had risen to 45 colonies or an estimated 200 beavers. It is encouraging to note that, in spite of annual trapping seasons since 1948, the population has increased. This project will supply beaver management information of value to national forest areas.

Necedah Refuge Deer Irruption

To be published soon is a summary of the irruption data for the Necedah National Wildlife Refuge in central Wisconsin which shows that the deer population increased from an estimated 200 in 1939 to a peak of 5,000 in 1946. The causes of the irruption can be attributed to the protection afforded the refuge deer, the Wisconsin Buck Law which prohibited the killing of does, and the lack of effective predators. Since 1945 archers harvested 356 deer, and since 1946 gun hunters killed 3,989. Before the irruption was brought under control by hunting, it had reached the stage in which fawns die of starvation. Because the sequence of events leading to the irruption of the Necedah Refuge deer herd is so well known, the information will be published with the hope that it will strike another blow for proper deer management.

PLANS FOR 1952

Although many long-time and continuing projects will absorb much of the time of the Station's staff for 1952, there is some opportunity to initiate new studies and to reconsider others already under way. The plans enumerated below give our best judgment as to the direction in which our efforts should be pointed during the coming year. It is only natural that other jobs will come up that will have to be fitted into our program. For this reason, the plans for 1952 purposely leave some room for short-time work. As in the past, we will welcome the advice and help of those interested in a forest research program. Advisory council meetings are scheduled for each research center and it is hoped through these councils to get further advice on program emphasis for 1952 and subsequent years.

As so frequently happens, the number of projects on which work is greatly needed exceed the time available. In the past year, through curtailment of funds, limitations on salary expenditures, and absorption of increased costs, the Station staff has been reduced by three people. Obviously, as the staff is reduced so also must the research program be kept to a manageable size.

Another factor of concern is the lack of balance in the Station program. This is true particularly in two phases; first, the lack of a Forest Utilization Service which has been so helpful to other forest experiment stations in forest management research; and second, the lack of work in the farm woodland area of southern Wisconsin and

Minnesota. Less than one man-year of staff time is available for research work in that area, yet there are over 6 million acres of farm woodlands and other small holdings which should be maintained in a state of high productivity. Plans for 1952 preclude initiation of a broad program in the woodland area, and it cannot be undertaken in future years until new financing is available.

Subject to the above comments, it is planned to emphasize the following studies in 1952:

Forest Management

1. Considerable emphasis will be given to work in the balsam fir type. This will receive greatest attention in "new work" planned at the Headwaters Forest Research Center. A study to determine best harvest cutting methods in mixed balsam fir-aspen will be established; a cooperative balsam fir thinning on a commercial basis in a stand not yet mature may be put in if suitable cooperation can be developed; and additional work will be done in balsam fir growth, mortality, seeding, and planting.

2. Cutting studies in aspen have thus far dealt with quaking aspen (Populus tremuloides), since over the Lake States as a whole this species predominates. In portions of lower Michigan and Wisconsin, however, bigtooth aspen (P. grandidentata) is more important. A cutting-methods study is being planned in bigtooth aspen in cooperation with the University of Michigan, American Box Board Company, Michigan Department of Conservation, and the Lower Michigan National Forest.

   An economic analysis of a noncommercial thinning established 20 years ago in quaking aspen is scheduled for completion; also a 20-acre test on the Pike Bay Experimental Forest of thinning an 11-year-old stand to determine the effects of density on yield and quality of the resultant stand.

3. Anticipating an increase in use of northern hardwoods for pulpwood during the next 10-20 years, the Station is completing installation of a comprehensive cutting test in second-growth stands of this kind on the Argonne Experimental Forest in Wisconsin. On 142 acres, 9 different treatments including clear cutting, strip cutting, and a range of conservative partial cuttings will be made. A block of 2½ to 10 acres will be devoted to each treatment, and each treatment will be tested in 3 different places. Some methods to be tried will be adaptable for sawlog forestry and others are aimed primarily at pulpwood production. Integrated utilization is planned so that the trees will be cut up into the products for which they are best adapted. Similar studies will also be initiated in the Upper Peninsula of Michigan.

4. The analysis of the survey of coniferous swamps in upper Michigan carried on the past two seasons with much cooperation from industry and public agencies will be completed and plans developed for intensive cutting tests.

5. In the follow-up of studies in mature northern hardwoods, a plan will be prepared for the recutting of experimental plots established 20-25 years ago in cooperation with Cleveland Cliffs Iron Company on the Upper Peninsula Experimental Forest. Twenty-year results of these experiments and related work are being written up into a comprehensive report for publication. In addition, a second cutting of mature stands will provide for tests on a pilot plant scale to determine how much growing stock should be held after cutting and how often to repeat the cuttings. An appraisal of decay and degrade caused by rot that follows logging injuries in partially cut stands started in 1951 in cooperation with the University of Michigan will be continued. Also to be started is a study to learn how to increase yellow birch reproduction following logging in the hardwood-hemlock type.

6. Since 1937 the Station has carried on many nursery experiments. These tests, together with practical experience, are to be written up in cooperation with Region 9, U. S. Forest Service, into a comprehensive report which, it is hoped, will subsequently be published as a government bulletin.

7. A "management unit" in pine types in which the most promising methods are put into practice has been installed on the Cutfoot Experimental Forest. A financial appraisal of management costs and returns for a 5-year period is under way. It should be completed in 1952.

   Preparatory to similar work in black spruce, a physical inventory and plan is to be made on the Big Falls Experimental Forest in cooperation with the Minnesota Forest Service. Other black spruce work will involve follow-through on the compartment study of cutting methods and an analysis of damage to advance growth resulting from various methods of cutting.

8. One of the first studies undertaken at the Lower Peninsula Research Center after establishment in 1948 was that of oak sites in the wood-lot section of Michigan in cooperation with Michigan State College. This is scheduled for completion in 1952 and it is hoped that the report can be published.

9. Cutting tests and demonstrations in beech-maple on a tract of wood-lot size, in cooperation with the Michigan Conservation Department, have been under way three years. A report analyzing costs and returns is planned. The search will be intensified to find suitable and available areas for similar work in oak and other forest types, if possible in State ownership where continuance of policy can be assured. A reconnaissance is planned to size up management possibilities in the lowland hardwood type. Much of this forest is in southern Michigan and the woods are parts of farms.

10. tests have now been installed over a wide area in red pine plantations in lower Michigan. It is planned to extend the study to white pine during the year in the same territory.

11. During the year a report will be prepared on the possibilities of pine release from overtopping hardwoods with chemicals. This work has been carried out in cooperation with the Lower Michigan National Forest.

12. The completion of another replication of the commercial pulpwood thinning experiment in planted red pine similar to the one installed in 1951 on the Higgins Lake State Forest is planned for the Huron National Forest in cooperation with national forest personnel.

A comprehensive report on North Dakota sand hills' planting experiments will be prepared.

Seed of some 30 different jack pine sources will be tested and sown in the nursery in cooperation with the University of Minnesota, the national forests, and several state and private agencies.

Forest Economics

In Minnesota the Forest Survey is scheduled for completion in two years. During 1952, considerable progress (see map) is expected. The Superior National Forest is planning to complete about 60 percent of the remaining job within their boundaries. The Iron Range Resources and Rehabilitation Commission is expected to complete portions of Cook and Lake Counties, to survey Koochiching County, and to cover a large area in southern Minnesota. A number of reports on areas already covered will be published during the year, including Beltrami, Becker, Wadena, Hubbard, Pine, and possibly Lake of the Woods Counties.

In Wisconsin the forest inventory is being conducted by three Conservation Department crews. The assignment of work is badly handicapped by lack of aerial photography for a number of counties. Depending upon receipt of new aerial photographs, it is expected the following areas will be completed in 1952: In central Wisconsin--balance of Monroe County, Jackson, Wood, Clark, and Eau Claire Counties; in northwestern Wisconsin--portions of Ashland County outside the Chequamegon National Forest, Iron and Burnett Counties; in northeastern Wisconsin--balance of Vilas and Oneida Counties, Langlade County, and part of Florence County. Computing and reporting of data for Portage, Waupaca, Waushara, Adams, and Marquette Counties will be stressed.

3. In Michigan the Forest Survey will continue with a small crew provided by the Conservation Department, the American Box Board Company, and this Station. Field work will be completed (see

map) in Oceana, Newaygo, and Mecosta Counties. Plans then call for covering Midland, Clare, Gladwin, Arenac, and Roscommon Counties and if possible also the portions outside the Huron National Forest in Ogemaw and Iosco Counties in 1952. Reports to be released include these counties: Baraga, Dickinson, Iron, Keweenaw, Houghton, Luce, Muskegon, Ottawa, Kent, Ionia, Montcalm, Isabella, Gratiot, Clinton, Shiawassee, Saginaw, and Bay Counties.

4. In 1952, drain statistics will be collected on pulpwood. All 52 Lake States' mills and 2 outside the region which obtain wood in the Lake States will be canvassed. For each mill the plan is to obtain data on pulpwood log and bolt receipts for 1951, indicating separately the volume of rough and peeled wood by species and source of wood by states.

   Such data enable the Station to estimate the annual drain on standing timber by wood-using industries drawing logs and bolts from the Lake States area. The information is used also to show the wood requirements of various forest industries and helps promote a better understanding of timber needs.

Forest Fire Research

Plans for future work include an over-all review of fire control in the Lake States, a study of behavior of large fires, and the analysis of data already collected as to the modifying effect of cover on the inflammability of prevailing forest-fire fuels.

Farm Forestry Studies

The farm forestry forties in the Upper Peninsula of Michigan and in northeastern Wisconsin will be given their seventh and sixth annual cuts respectively. Results of the first 5-year cutting cycle on the upper Michigan "forty" will be published. Additional growth data will be obtained from the Wisconsin Timber Harvest Forest and articles will be prepared in cooperation with state agencies. In Minnesota additional work will be done with the vacuum process in an attempt to determine satisfactory treating schedules for seasoned jack pine posts and to develop more effective methods for treating tamarack posts. A semi-technical experiment station bulletin, "Fencing for a Lifetime with Treated Wooden Posts," will be written.

Wildlife Studies

The deer exclosure project will be expanded to include exclosures on the Wisconsin national forests. No other projects are planned, although consideration will be given to: (1) a study of the effect of various degrees of deer browsing on the growth and survival of important browse plants; (2) a cooperative study on the methods of cutting swamps in relation to food production for deer; (3) an evaluation of the wildlife aspects of controlled burning experiments; and (4) a cooperative study of deer and snowshoe hare tree repellents.

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PERSONNEL 1951

Administration - Murlyn B. Dickerman, Director
Jerry Roch, Administrative Officer
Charlotte L. Devine, Clerk
Helen A. Woodworth, Clerk-Stenographer
Adele M. Gibney, Clerk-Stenographer
M. Evelyn Wright, Stenographer
Helen L. Larson, Stenographer

Forest Management - Francis H. Eyre, Forester, In Charge
Paul O. Rudolf, Forester
Suren R. Gevorkiantz, Forester
Lucille P. Olsen, Statistician
John R. Neetzel, Forester (Farm Forestry, in cooperation with the University of Minnesota)

Field Stations

Headwaters Forest Research Center, Grand Rapids, Minnesota
Lawrence P. Neff, Forester, In Charge
Eugene I. Roe, Forester
Miron L. Heinselman, Forester
Lee S. South, Forestry Aide
Archie V. English, Clerk

Northern Lakes Forest Research Center, Rhinelander, Wisconsin
Joseph H. Stoeckeler, Forester, In Charge
Carl Arbogast, Jr., Forester
Harold F. Scholz, Forester
Edward R. Stoltz, Clerk

Lower Peninsula Forest Research Center, East Lansing, Michigan
John L. Arend, Forester, In Charge
LaMont G. Engle, Forester
Robert A. Ralston, Forester
Viola I. Meyer, Clerk (to 11/7/51)
Mary H. Seaman, Clerk
Leslie W. Gysel, Collaborator

Upper Peninsula Experimental Forest, Marquette, Michigan
Walter M. Zillgitt, Forester, In Charge (to 6/15)
Zigmond A. Zasada, Forester, In Charge (from 6/15)
Franklin R. Longwood, Forester
Wilho A. Salminen, Forestry Aide
Gloria D. Matson, Clerk

Dakota Plains Forest Research Center, Denbigh, North Dakota
Inactive

Fire Control - J. Alfred Mitchell, Forester

Forest Economics - Russell N. Cunningham, Forester, In Charge

Economics of Management and Utilization
Howard W. Mayne, Forester

Forest Survey
Arthur G. Horn, Forester
Clarence D. Chase, Forester
Paul C. Guilkey, Forester
Robert A. Hartwick, Forester (to 10/29)
Jacob T. Vander Sys, Agricultural Aide (from 10/29)

Statistics
Suren R. Gevorkiantz, Forester
Lucille P. Olsen, Statistician
Maryan J. Anderson, Statistical Clerk

Forest Biology (Fish & Wildlife Service, U. S. Department of Interior)
Laurits W. Krefting, Biologist
Ruth Dalby, Clerk-Stenographer